NASA TECH BRIEF
Ames Research Center

Fire Retardant Polyisocyanurate Foam

The problem:

To increase the fire retardant properties of low-density polymer foams.

The solution:

A polyisocyanurate foam with pendant nitrile groups which form thermally-stable heterocyclic structures at a temperature below the degradation temperature of urethane linkages.

How it's done:

The nitrile groups are introduced as acrylonitrile grafted to a low-hydroxyl number polyol prepolymer which may be of the type typically derived from glycerin and propylene oxide. Because the modified polyol has a low hydroxyl number and low functionality, the resulting polyisocyanurate-polyurethane foam structure has mechanical flexibility, whereas the polyisocyanurate polymers do not. The polymeric structures containing nitrile groups cyclize at low temperatures to form nitrogen-containing heterocyclic ring structures; subsequent degradation of these structures and the polyisocyanurate-urethane structures at an elevated temperature provides a high char yield, implying a correspondingly lowered yield of the volatile flammable species which are formed in comparatively large quantities by state-of-the-art polyurethane polymer foams based on polyols such as sucrose and glucose.

The new type of rigid foam is typically prepared by homogenizing in a ball mill a mixture of the polyol grafted with acrylonitrile, a tertiary amine catalyst, an inorganic base, a char stabilizer such as potassium fluoborate, and a blowing agent. Grinding is continued until all dispersed solids are reduced at least to a diameter of 50×10^{-3} mm. It may be desirable to incorporate other polymeric materials (such as poly (vinyl chloride–vinyl acetate) copolymer) and inert refractories such as silica to increase density or to impart particular properties to the finished foam; other additives may be materials such as encapsulated flame retardants, cell stabilizers, colorants, etc. The premix formed by milling is then blended rapidly and thoroughly with a polymeric isocyanate, for example, a polymethylene polyphenyl isocyanate, and immediately poured into a mold to cure for about 16 to 24 hours.

When exposed to a JP-4 fire at a heat flow rate of 10–13 Btu/ft^2 sec ($11.1 - 14.8 \times 10^4$ W/m^2), 5-cm thick state-of-the-art polyisocyanurate foams burn through in about 55 seconds; in contrast, the new type of polyisocyanurate foams withstand burn-through for more than 600 seconds.

Reference:

Riccitiello, S. R.; Fish, R. H.; Parker, J. A.; and Gustafson, E. G.: Development and Evaluation of Modified Polyisocyanurate Foams for Low-Heating-Rate Thermal Protection. Journal of Cellular Plastics, vol. 7, no. 2, page 3, 1971.

Note:

No additional documentation is available. Specific questions, however, may be directed to:

Technology Utilization Officer
Ames Research Center
Moffett Field, California 94035
Reference: B72-10269

(continued overleaf)

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to:

Patent Counsel
Mail Code 200-11A
Ames Research Center
Moffett Field, California 94035

Source: Salvatore R. Riccitiello and
John A. Parker
Ames Research Center
(ARC-10280)